Logical reasoning in schizotypal personality[1]

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Abstract

It was examined whether psychotic-like personality traits in a sample of 205 college students could predict logical reasoning deficits, akin to those seen in schizophrenia. The participants were tested on their ability to assess the logical validity of premises (Logical Reasoning Task), and completed a multi-dimensional schizotypy inventory (O-LIFE). Low accuracy was associated with increased levels of disorganized schizotypy ('Cognitive Disorganization'), while elevated errors were associated with increased levels of positive ('Unusual Experiences'), negative ('Introvertive Anhedonia') and impulsive ('Impulsivity Non-conformity') schizotypy. Nevertheless, multiple regression analyses revealed that negative schizotypy was retained as the only significant predictor after performance was corrected for random guessing, and the contribution of the average amount of time spent on each premise was controlled. The results suggest that, although most schizotypy dimensions have a detrimental effect on reasoning performance, possibly due to disadvantageous test-taking strategies, negative schizotypy is the most reliable predictor of logical reasoning deficits. It is proposed that social/interpersonal schizotypal traits, like negative symptoms of schizophrenia, are accompanied by deficient executive functions of working memory, which appear to undermine, *inter alia*, logical reasoning processing.

Key words: executive functions; impulsivity; logical reasoning; negative schizotypy; schizophrenia; social/interpersonal deficits; working memory;

A failure to reason by conventional logical rules has been frequently considered to be a salient deficit in schizophrenia (Watson & Wold, 1981; Watson, Wold, & Kucala, 1976; Williams, 1964). Despite the early mixed evidence, recent research has confirmed that schizophrenic patients tend to demonstrate logical reasoning deficits in a wide range of tasks (Glicksohn, Alon, Perlmutter, & Purisman, 2001; Goel, Bartolo, St. Clair, & Venneri, in press; Mujica-Parodi, Malaspina, & Sackeim, 2000). Relevant to the literature above, the presence of negative symptoms in schizophrenia has been consistently associated with poor performance on the Wisconsin Card Sorting Task (e.g., Butler, Jenkins, Sprock, & Braff, 1992; Voruganti, Heslegrave, & Awad, 1997), a rule-learning task, which is thought to assess general reasoning ability as well (see Lezak, 1995).

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The executive functions of working memory, responsible for keeping on-line and manipulating information during the execution of complex cognitive tasks, seem to be critically involved in logical reasoning processing (Baddeley, 1986). Accordingly, the demonstrated logical reasoning deficits in schizophrenia seem in line with evidence that schizophrenic patients are characterized by deficient executive functioning, mainly working memory (e.g., Goldberg, Weinberger, Berman, Pliskin, & Podd, 1987; Goldman-Rakic, 1994; Riley, McGovern, Mockler, Doku, O'Ceallaigh, & Fannon, 2000). In accord with continuum views of schizophrenia (Claridge & Broks, 1984; Eysenck & Eysenck, 1975), executive functioning deficits have also been detected in non-clinical participants who score highly on psychometric measures of schizotypy (e.g., Poreh, Ross, & Whitman, 1995; Suhr, 1997; Tsakanikos & Reed, 2003).

It has been argued (e.g., Mujica-Parodi et al., 2000) that many of the aforementioned studies on logical reasoning deficits in schizophrenia might be flawed because of the heterogeneity of patient samples, as well as possible floor effects due to generalized deficits, medication, poor motivation, disruption caused by active psychotic symptomatology etc. Given that such problems are not uncommon in patient samples, clinical research is often complemented through assessing healthy individuals who score highly on psychometric measures of schizotypy. However, it has not been established whether or not logical reasoning deficits could be predicted by psychometrically assessed, psychotic-like features.

Factor-analytic studies have revealed four factors underlying the construct of schizotypy (Bentall, Claridge, & Slade, 1989; Vollema & Van den Bosch, 1995). Following such a multi-dimensional approach, the Oxford–Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason, Claridge, & Jackson, 1995), assesses four dimensions of schizotypy. The first three dimensions correspond to a three-factor model of schizophrenia (Liddle, 1987): a positive ('Unusual Experiences'), a negative ('Introvertive Anhedonia'), and a disorganized dimension ('Cognitive Disorganization'). The fourth dimension ('Impulsivity Non-conformity') refers to the impulsive and aggressive aspects of psychosis, and it is based on the 'Psychoticism' scale (Eysenck & Eysenck, 1975). Various studies have confirmed that high-schizotypy scorers, as identified by the O-LIFE sub-scales, demonstrate neuro-cognitive deficits akin to those of the schizophrenic patients (Burch, Steel, & Hemsley, 1998; Goodarzi, Wykes, & Hemsley, 2000; Rawlings & Goldberg, 2001; Tsakanikos & Reed, 2003), attesting to the experimental validity of these scales.

Despite the reported logical reasoning deficits in schizophrenia (Glicksohn et al., 2001; Goel et al., in press; Mujica-Parodi et al., 2000) there is no evidence for similar deficits in schizotypy, although impaired performance on executive functioning tasks has been specifically associated with negative schizotypy (Poreh et al., 1995; Suhr, 1997; Tsakanikos & Reed, 2003). Paradoxically, schizotypy measures, and particularly the 'Impulsivity Non-conformity' scale, were found in one study to be positively associated with the number of correct responses on a logical reasoning task (Oaksford & Sellen, 2000). This latter finding is not only inconsistent with the schizophrenia literature, but it also appears incongruent with the individual-differences

literature, given that impulsivity has been specifically associated with impaired logical reasoning performance (Schweizer, 2002).

One possible explanation for the above discrepancy could be that different schizotypy dimensions may be associated with different test-taking strategies, coupled with evidence that the tendency to act with relatively little forethought can be advantageous in certain tasks (Dickman, 2000; Tsakanikos & Reed, 2003). For example, impulsive aspects of schizotypy might be associated with proneness to random guessing, responding with little forethought, fast decisions etc. Although such strategies could be advantageous in certain tasks by increasing the probability of correct responding (e.g., by not leaving unanswered items), the same strategies could be disadvantageous in tasks where such a possibility can be statistically controlled.

The present investigation examined the relationship between different aspects of performance on logical reasoning, as assessed by a typical task of logical reasoning (Logical Reasoning Task; Baddeley, 1968), and different schizotypy dimensions (O-LIFE; Mason et al., 1995). Given that executive functioning appears to be critically involved in logical operations (Baddeley, 1986), and taking into account the reported association between the negative symptoms of schizophrenia and deficient executive functioning (Goldberg et al., 1987; Goldman-Rakic, 1994; Riley et al., 2000), it was predicted that logical reasoning deficits would be primarily associated with negative schizotypy. The possible contribution of other dimensions of schizotypy, such as 'Impulsivity Non-conformity, was expected be limited to performance parameters reflecting certain test-taking strategies, such as fast decision-making and proneness to random guessing.

To test the above hypotheses, non-clinical participants completed the O-LIFE schizotypy scales (Mason et al., 1995) and were tested on the Logical Reasoning Task (Baddeley, 1968). Simultaneous multiple regression analyses (method: 'ENTER'; SPSS 10.1) with schizotypy scores as predictor variables were performed at two successive phases. In the first phase, correct (accuracy) and incorrect responses (errors) on the Logical Reasoning Task were analysed separately. In the second phase, a multiple regression analysis was performed on the overall reasoning performance after correcting for random guessing, and controlling for the average amount of time spent on each item of the task.

Method

Participants

Two hundred and five participants (86 males and 119 females), mostly undergraduate students recruited at the UCL campus, took part in this study. Their age ranged from 17 to 38 (M = 21.3, SD = 3.5) and were naïve to the purpose of the investigation.

Schizotypy measures

The Oxford–Liverpool Inventory for Feelings and Experiences (O-LIFE) consists of 159 items selected on the basis of factor-analytic studies of scales that have been employed in the past to assess psychotic-like features in the

general population (Bentall et al., 1989; Mason et al., 1995). More specifically, it assesses the following four dimensions:

'*Unusual Experiences*' reflects the positive symptoms of psychosis, and consists of items assessing magical thinking, unusual perceptual aberrations, and hallucinatory experiences (e.g., "When in the dark do you often see shapes and forms even though there is nothing there?"; "Are your thoughts sometimes so strong that you can almost hear them*?*").

'*Cognitive Disorganization*' reflects the disorganized aspect of psychosis, and consists of items assessing difficulties with concentration and decision making, as well as social anxiety (e.g., "No matter how hard you try to concentrate do unrelated thoughts always creep into your mind?"; "Are you sometimes so nervous that you are blocked?").

'*Introvertive Anhedonia*' reflects the negative aspects of psychosis, and consists of items assessing the lack of enjoyment from social contact, physical activities, coupled with aversion to emotional and physical intimacy (e.g., "Are you much too independent to get involved with other people?"; "Are people usually better off if they stay aloof from emotional involvements with people?").

'*Impulsive Non-conformity*' consists of items assessing aggressive, anti-social and impulsive behaviour (e.g., "Were you ever greedy by helping yourself to more than your share of anything?"; "Do you ever feel the urge to break or smash things?").

Logical reasoning

The Logical Reasoning Task is a typical measure of reasoning ability proposed by Baddeley (1968). It is a timed task (3 min), and consists of 64 items/problems. In each item, two possible pairings (AB or BA) are presented with either an accurate descriptor (logically valid premise), or an inaccurate descriptor (logically invalid premise). Evaluation of the premises requires both grammatical transformation and spatial-relational inference (e.g., "B follows A", "A is not preceded by B", "B is not followed by A" etc). The participants were instructed to indicate whether each premise is true (T) or false (F). All the participants received six warm-up trials before the actual timed task, and were tested individually.

Number of correct (accuracy) and incorrect (errors) responses were the main dependent measures. In addition, two performance parameters were calculated. The average processing time, i.e. average time allocated on each attempted item, was calculated by dividing the time available to complete the task by the total number of attempted items (180 sec/ total attempted items). In order to obtain a single index of reasoning performance after correcting for random guessing, a typical formula for correction (e.g., Ekstrom et al., 1976) was applied: $R - W / n - 1$, were R = number right, W = number wrong, and n = the number of response options for each item.

Procedure

The participants were informed that they were taking part in a study assessing individual differences in personality and cognitive processing, and were tested individually.

Results

Inter-correlations

Table 1 presents the means, the standard deviations, and the inter-correlations between the O-LIFE scales, and the number of correct and incorrect responses. The means and the standard deviations for the O-LIFE scales were similar to those reported in the original study (Mason et al., 1995), as well as those reported in later studies (e.g., Rawlings & Goldberg, 2001; Tsakanikos & Reed, 2003). In addition, the obtained inter-correlations between the O-LIFE scales were consistent with similar results in previous studies. The only exception was the absence of a significant correlation between 'Impulsivity Non-conformity' and 'Introvertive Anhedonia' (in the Mason et al. study, $r = -0.10$, $p < 0.05$). However, given that the correlation between these two scales was low in both studies, this deviation could be due to the difference in the sample size between the original study (N = 508) and the present investigation (N = 205). Finally, inspection of Table 1 reveals that they were various significant correlations between schizotypy and reasoning measures, suggesting that, overall, increased levels of schizotypy were associated with poor performance on the Logical Reasoning Task.

Table 1 about here

Regression analyses

i. Correct and incorrect responses on the Logical Reasoning Task

There was a relatively low correlation ($r = -0.25$, $p < 0.01$) between the number of correct responses (*mean* = 27.89, *SD* = 11.75) and number of incorrect responses (*mean* = 6.77, *SD* = 4.81) on the Baddeley's Logical Reasoning Task, suggesting that the two measures, although related, maintained a substantial amount (> 94%) of non-shared variance. In order to examine whether schizotypy scores could predict performance on the reasoning task, while controlling for inter-correlation between the scales and the contribution of correct/incorrect responses, two multiple regression analyses were performed. In the first analysis, the number of correct responses on the reasoning task was the dependent variable. The four O-LIFE scales were entered in the regression equation as predictor variables along with the number of incorrect responses on the reasoning task. The overall equation was significant, $F_{(5, 200)} = 5.01$, $p < 0.001$, accounting for about 9% of the total variance (adjusted R^2).

Table 2 about here

Table 2 presents the regression coefficients for the individual predictor variables. Inspection of Table 2 suggests that only 'Cognitive Disorganisation' and number of incorrect responses on the reasoning task made significant independent contributions to the dependent variable. The regression slopes for these variables were negative, suggesting that an average increase in each of them was associated with a decrease in the dependent variable.

In the second multiple regression analysis, the number of incorrect responses on the Logical Reasoning Task was the dependent variable. The mean scores on the four O-LIFE scales were entered in the regression equation as predictor variables along with the number of correct responses on the reasoning task. The overall equation was significant, $F_{(5, 200)} = 8.03$, $p < 0.001$, accounting for about 15% of the total variance (adjusted R^2). Table 3 presents the regression coefficients for the individual predictor variables. Inspection of Table 3, suggests that, apart from 'reasoning errors', only 'Introvertive Anhedonia' and 'Impulsivity Non-conformity' made statistically significant, independent contributions to the dependent variable. The regression slopes in these two schizotypy measures were negative.

Table 3 about here

The above set of regression analyses revealed that different dimensions of schizotypy were associated with different aspects of performance on the Logical Reasoning Task. Increased levels of 'Cognitive Disorganisation' were associated with reduced number of correct responses on the task, although increased levels of 'Impulsivity Non-conformity' and 'Introvertive Anhedonia' were associated with an increased number of incorrect responses.

ii. Corrected scores on the Logical Reasoning Task after controlling for average processing time

It could be suggested that the above results reflect different test-taking strategies in terms of the average time allocated on each attempted item. For example, it could be argued that, given the time-constrained nature of the task, participants who systematically allocated more time on each attempted item were more likely to achieve a lower overall number of correct responses. Additionally, it could be claimed the results reflect differences in terms of the detection criterion employed. For example, participants with elevated levels of 'Impulsivity Non-conformity' might have employed a rather 'loose' detection criterion involving random guessing, and, therefore, more prone to errors. In order to address the above possibilities, analysis was then run for overall reasoning performance after correcting for random errors and after controlling for the average time spent on each item.

Table 4 about here

The average processing time (mean = 5.9 sec, SD = 2.4 sec), and the corrected scores (mean = 21.1, SD = 14.9) were moderately correlated (r = -.49, p < .01), retaining a considerable amount (> 75%) of non-shared variance. In a final multiple regression analysis, the corrected scores on the reasoning task were entered as a dependent variable. The schizotypy scores were entered as predictor variables along with the average processing time. The overall regression equation was significant, $F_{(5, 200)}$ = 17.12 , p < 0.001, accounting for about 28% of the total variance (adjusted R^2). Table 4 presents the regression coefficients for the individual predictor variables. Inspection of Table 4 reveals that all the predictors were negatively associated with the corrected scores on the logical reasoning task. However, only 'average processing time' and 'Introvertive Anhedonia' were significant predictors of the dependent variable.

Discussion

The present investigation examined performance parameters on a typical logical reasoning task as a function of different schizotypy dimensions. Increased incidence of psychotic-like features in a sample of undergraduate students was associated with poor performance in logical reasoning. These results suggest that psychometrically defined, high-schizotypy scorers demonstrate logical reasoning deficits akin to those seen in schizophrenic patients (Glicksohn et al., 2001; Goel et al., in press; Mujica-Parodi et al., 2000). Moreover, successive multiple regression analyses showed that different schizotypy dimensions were independently associated with different aspects of performance. Negative schizotypy and 'Impulsivity Non-conformity" were independently associated with reasoning errors. This latter finding concurs with prior evidence that impulsivity has a detrimental effect on reasoning performance (Schweizer, 2002).

Elevated levels of 'Cognitive Disorganization' were negatively associated with reasoning accuracy, possibly due to concentration difficulties tapped by this scale. However, when more conservative criteria were applied in the analysis (i.e. performance was statistically controlled for random guessing and average time spent on each item) negative schizotypy remained the most reliable predictor of performance.

Given that logical reasoning ability seems largely dependent upon the executive functions of working memory (Baddeley, 1986), the obtained pattern of results accords with prior evidence on executive deficits as a function of negative symptoms of schizophrenia   (e.g., Goldberg et al., 1987; Goldman-Rakic, 1994; Riley et al., 2000), and negative schizotypy (e.g., Poreh et al., 1995; Suhr, 1997; Tsakanikos & Reed, 2003). An alternative account could be that the above results reflect differences in terms of general ability. However, this account seems less likely, because general intelligence, assessed by various standardized IQ measures, has been consistently found

to be unrelated to psychometric schizotypy (Poreh et al., 1995; Suhr, 1997; Tallent & Gooding, 1999; Tsakanikos & Reed, 2003).

A possible account for the effects of the impulsive and disorganized aspect of schizotypy is that these were effects due to individual differences in random guessing and average time spent on each item. This account is supported by the fact that the contribution of these two measures was eliminated after the latter performance parameters were statistically controlled. Individual differences in certain traits, such as the impulsive and disorganized psychotic-like features, may relate to different cognitive strategies that could be either advantageous or disadvantageous, depending on the nature of the task. This may explain why, for example, impulsivity has been associated with enhanced performance on some occasions (Oaksford & Sellen, 2000), while on other occasions, including the present investigation, with poor performance (Schweizer, 2002). Unfortunately, the possible contribution of such differences to reported neuro-cognitive deficits has been largely neglected in the clinical literature.

In conclusion, the present investigation showed that college students who endorsed an increased number of social-interpersonal schizotypal traits ('negative' schizotypy) were more likely to perform poorly on the Logical Reasoning Task. Logical reasoning deficits might be an index of the severity of 'executive' deficits within working memory associated with social/inter-personal schizotypal traits. If this is the case, then a relative failure to reason by conventional logical rules in people scoring highly on psychometric measures of psychosis-proneness may be an additional vulnerability marker, identifying individuals who are at a particular risk for developing fully-fledged psychotic symptoms. This latter possibility may well deserve further attention in forthcoming longitudinal studies.

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Acknowledgements

Table 1
Inter-correlations between the schizotypy scales and the performance measures
on the Logical Reasoning Task.

	M	SD	1	2	3	4	5	6
'Unusual Experiences'	9.55	5.74	-					
'Cognitive Disorganization'	11.57	5.13	0.48**	-				
'Introvertive Anhedonia'	6.01	4.41	0.22**	0.09	-			
'Impulsive Non-conformity'	10.19	5.11	0.26**	0.14*	-0.01	-		
Correct Responses	27.89	11.75	0.07	-0.17*	0.03	0.06	-	
Incorrect Responses	6.77	4.81	0.22*	0.09	0.25**	0.16*	-0.24**	-

* $p < 0.05$ (two-tailed)
** $p < 0.01$ (two-tailed)

Table 2
O-LIFE scores and number of incorrect responses as predictor variables for the
number of correct responses on the Logical Reasoning Task

Predictor variable	B	SEB	Beta	t
Incorrect responses	-0.48	0.12	-0.28	-4.02**
'Unusual Experiences'	0.04	0.16	0.02	0.32
'Cognitive Disorganization'	-0.43	0.18	-0.19	-2.45*
'Introvertive Anhedonia'	0.28	0.18	0.11	1.54
'Impulsive Nonconformity'	0.28	0.16	0.12	1.76

*$p < 0.05$ (two-tailed)
**$p < 0.001$ (two-tailed)

Table 3
O-LIFE scores and number of correct responses as predictor variables for the
number of incorrect responses on the Logical Reasoning Task

Predictor variable	B	SEB	Beta	t
Correct responses	-0.15	0.04	-0.26	- 4.02***
'Unusual Experiences'	0.16	0.09	0.14	1.82
'Cognitive Disorganization'	0.08	0.09	0.06	0.83
'Introvertive Anhedonia'	0.35	0.10	0.22	3.46**
'Impulsive Non-conformity'	0.19	0.08	0.14	2.17*

*$p < 0.05$ (two-tailed)
**$p < 0.01$ (two-tailed)
***$p < 0.001$(two-tailed)

Table 4

O-LIFE scores and average processing time as predictor variables for the
corrected scores on the Logical Reasoning Task

Predictor Variable	B	SEB	Beta	t
Average processing time	-3.23	0.37	-0.51	-8.57**
'Unusual Experiences'	-0.28	0.18	-0.10	-1.52
'Cognitive Disorganization'	-0.22	0.19	-0.07	-1.12
'Introvertive Anhedonia'	-0.46	0.20	-0.13	-2.20*
'Impulsive Non-conformity'	-0.08	0.18	-0.02	-0.46

*$p < 0.01$ (two-tailed)
**$p < 0.001$(two-tailed)